PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in Feel Simulators for Aircraft

We, H. M. HOBSON LIMITED, of Africa House, Kingsway, London, W.C.2, a British Company do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The purpose of an artificial feel simulator for aircraft is to synthesize at the control column stick forces which are a function of the aerodynamic effectiveness of the relevant aircraft control surfaces. Ideally the rate of change of stick force with displacement of the control surface should, under all conditions of flight and aircraft loading, be directly proportional to the effectiveness of the surface. However, in the case of transport aircraft, which are subject to a wide variation in aircraft loading and position of the centre of gravity C.G., there is no unique function of aircraft speed, altitude, Mach number and other factors which allows this ideal to be fulfilled without fairly large errors. It is also known that the tailplane trim position tends to be a function of the C.G. position of the aircraft and that the inclusion of a term representative of C.G. position can help to minimise the errors in stick forces.

The invention provides a hydraulic feel simulator for an aircraft having a tailplane which is adjustable to vary the trim of the aircraft, which imposes on the control column a hydraulic control pressure P opposing movement of the control column in the sense to adjust the elevator which pressure varies as an increasing function and preferably linearly with the displacement D of the tailplane from its neutral position, the rate of increase of said function suddenly becoming smaller at a value of D determined by q, the difference between total pressure P_t and static pressure P_s, said change-over value of D decreasing as q increases.

The invention will now be further described with reference to the drawings accompanying the Provisional Specification, in which:—

Fig. 1 illustrates graphically the relationship between the hydraulic control pressure P and the displacement or angular position D of the tailplane,

Fig. 2 is a diagram of the complete feel simulator and

Fig. 3 is a vertical section through the feel simulator control mechanism.

Referring first of all to Fig. 2, the tailplane 10 is adjustable by a conventional control mechanism with reference to the body of the aircraft about an axis 11 to vary the trim of the aircraft. The elevator 12 is adjustable in relation to the tailplane 10 by a mechanical linkage 13 connected to the control column 14, which is pivoted at 20 to the aircraft structure.

The feel simulator includes a control mechanism 15 (shown in detail in Fig. 3) which generates in a signal line 16 connected to a cylinder 17 a control pressure P which varies with D, the displacement of the tailplane 10 from its neutral position, as later described. The cylinder 17 is pivoted at 18 to the aircraft structure and contains a piston 19, the piston rod 21 of which is pivoted at 22 to the control column 14.

The control mechanism 15 is adjusted, as later described by a linkage 23 in conformity with changes in the position of the tailplane 10.

As will be noted from Fig. 1, the control pressure P varies linearly with D as indicated by the line qo but $\frac{dP}{dD}$ changes suddenly,

at different values of q indicated by the points 1, 2, 3 and max, the rate of increase in P with increase of D being thereafter decreased as represented by the lines q1, q2, q3, q max. The relationship between P and D is therefore defined by the equation P=kD where k is a term which changes from one fixed value to a smaller fixed value at a value of D which decreases with increase in q.

The control mechanism 15, see Fig. 3, includes a housing 23 divided into upper and lower chamber 24, 25 by a diaphragm 26 which is connected by a flexible seal 27 to a control rod 28 which bears at its lower end against the top of a control valve 31 subjected at its undersurface to the control pressure P in the signal line 16. Total pressure P_t is applied to the chamber 25 through an inlet 29 and static pressure P_s is applied to the chamber 24 through an inlet 30. A fail safe valve 32 is provided between the rod 28 and the valve 31. Springs 33, 34 are interposed between the housing 23 and retainers 35, 36 fixed to the rod 28, and a spring 37 abuts against the underside of the diaphragm 26. A spring 38 applies pressure to the upper surface of the diaphragm 26 and a spring 39 applies pressure to the upper end of the rod 28. A cam shaft 40, which is rotatable by linkage 23 (Fig. 2) so that its position is representative of the displacement D of the tailplane from its neutral position, carries a cam 41 which adjusts the compression of the spring 39 and a two-lobed cam 42 which adjusts the compression of the spring 38. As D increases the cams serve to increase the compression of the spring 39 and to reduce the compression of the spring 38.

The valve 31 normally occupies a neutral position in which the control pressure P acting on its undersurface is balanced by the downward load on it. On increase in the downward load, the valve 31 moves down to connect the signal line 16 to a pressure inlet 43, so causing P to increase to a value at which it again balances the downward load and restores the valve 31 to its neutral position. On decrease in the downward load, the valve 31 moves up to connect the signal line 16 to an exhaust outlet 44, so causing P to fall to a value at which it balances the decreased downward load.

At low values of q, the diaphragm 26 is held against a stop 44A on the housing 23 and the downward load on the valve 31 is determined by the spring 39, the valve being relieved of load from the diaphragm 26 and the spring 38. As the displacement D of the tailplane is increased the compression on the spring 39 will be increased and P will be increased progressively with D as indicated by the line qo in Fig. 1.

The compression of the spring 38 is decreased as D is increased. When q reaches a value sufficient to overpower the spring 38, and this will be greater the less the value of D, the diaphragm 26 will be lifted into contact with a stop 45 attached to the upper end of the rod 28. The rod will then be subject to a downward load from the spring 38 in addition to the downward load from the spring 49, but as the compression of the spring 38 is reduced on further increase in D, the rate of change of P in response to tailplane movements will thereafter be reduced and the relation between P and D will thereafter follow the appropriate line q1, q2 etc as shown in Fig. 1.

WHAT WE CLAIM IS:—

1. A hydraulic feel simulator, for an aircraft having a tailplane which is adjustable to vary the trim of the aircraft, which imposes on the control column a hydraulic control pressure P opposing movement of the control column in the sense to adjust the elevator, which pressure varies as an increasing function with the displacement D of the tailplane from its neutral position, the rate of increase of said function suddenly becoming smaller at a value of D determined by q, the difference between total pressure P_t and static pressure P_s, said change-over value of D decreasing as q increases.

2. A feel simulator as claimed in claim 1, in which the function varies linearly with the displacement of the tailplane from its neutral position.

3. A feel simulator as claimed in claim 2, which includes a hydraulic cylinder coupled to the control column, a signal line for maintaining the control pressure P in the cylinder, a control valve, subject at one end to the control pressure P and at the other to the pressure of a spring, for controlling the pressure P in the signal line and maintaining it equal to the pressure of the spring, a cam mechanism operatively connected to the tailplane and effective to increase the pressure of the spring, and therefore the control pressure P, with increase in the displacement D of the tailplane, a diaphragm connected to the control valve and subject at one side to a pressure representing q and a second spring, the load of which is decreased by the cam mechanism as D increases, acting upon the other side of the diaphragm and urging it towards the control valve, the diaphragm being maintained by the second spring against a stop at low values of q to relieve the control valve of the load of the second spring but being arranged to move, on increase of q to a value at which it overpowers the second spring, into contact with a second stop so that the control valve is thereafter subject to the pressure of both springs.

4. A feel simulator as claimed in claim 1, substantially as described herein with reference to the drawings accompanying the Provisional Specification.

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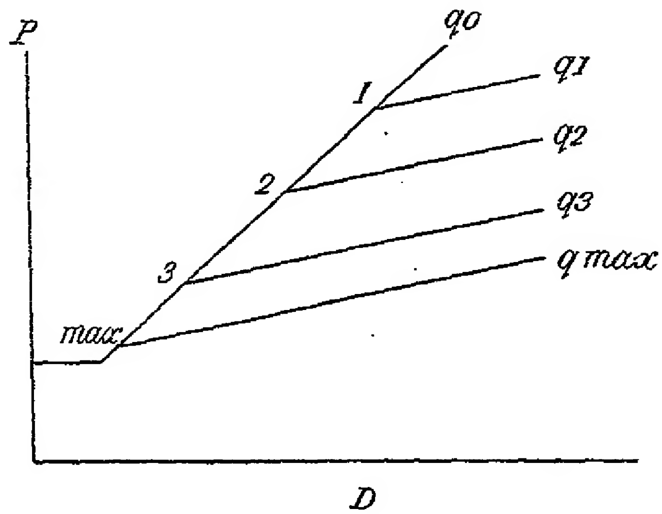
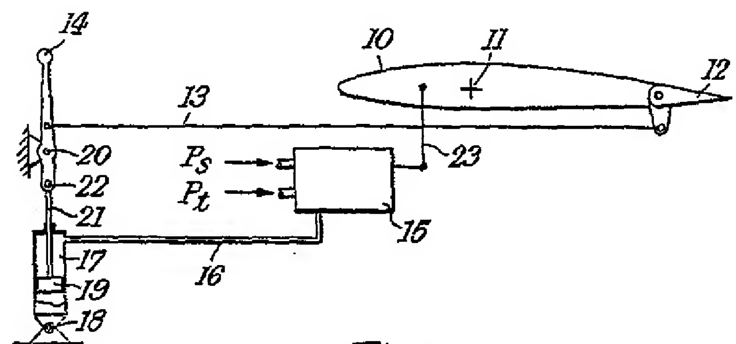


P
qo
q1
q2
q3
q max
1
2
3
max
D

Fig. 1.



14
10
11
12
13
20
22
21
17
19
18
16
15
23
P_s
P_t

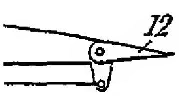
Fig. 2.

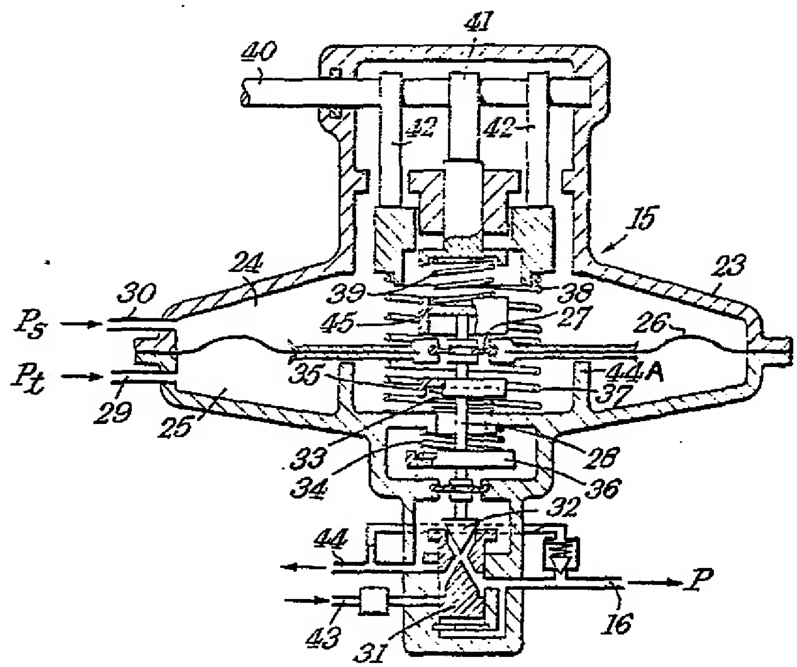
'1

'2

'3

'max

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15
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23
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39
38
P_S
45
27
26
35
44A
P_t
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25
33
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32
44
P
43
31
16

Fig. 3.

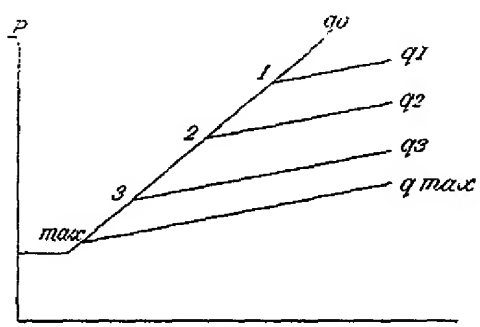

Fig. 1.

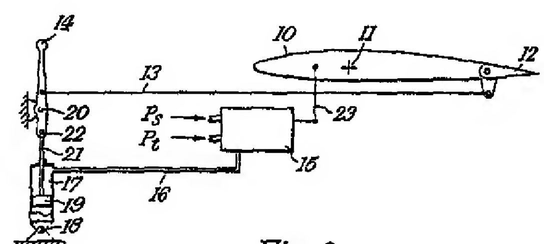

Fig. 2.

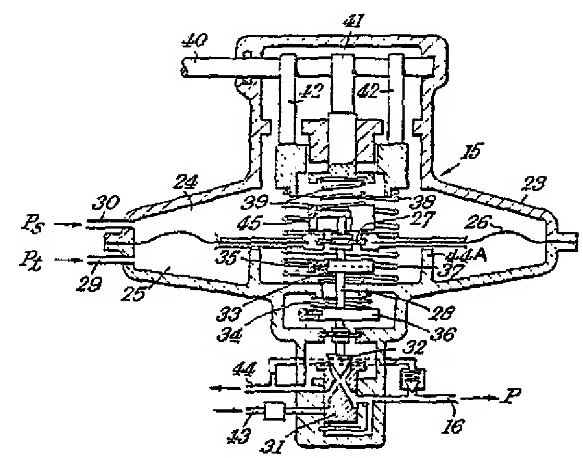

Fig. 3.